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(54) Title: PROCESS FOR ADJUSTING LUBRICANT OIL DROPLET SIZE IN AN ALUMINUM ROLLING MILL

(57) Abstract

A process is described for rolling aluminum products in which the aluminum is passed between rolls of a rolling mill and rolling bite friction is controlled by applying to the rolls or less often to the aluminum being rolled a lubricant comprising an oil–in–water emulsion having a specific oil droplet size. According to the novel feature, the oil droplet size is adjusted by either (a) blending the emulsion components from a multi–tank storage or (b) passing a large droplet size emulsion through an homogenizer or mixer to obtain droplets of a desired size. The droplet size is selected to optimize the roll bite friction requirements of different sheet aluminum products or rolling mills or to compensate for emulsion degradation due to ageing.

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Process for Adjusting Lubricant Oil Droplet Size in an Aluminum Rolling Mill

Technical Field

The present invention relates to the operation of rolling mills for rolling aluminum (including aluminum alloys) and in particular to the lubrication of the aluminum during the rolling process.

Background Art

It is well known in the rolling of aluminum to employ a rolling lubricant in the form of an oil-in-water emulsion. For example, Dowd et al. U.S. Patent 3,192,752, issued July 6, 1965, describes the use of an oil-in-water emulsion as both the coolant and the source of oily lubricant in the continuous cold rolling of aluminum strip in a multi-stand rolling mill. In this process, an oily lubricant of given composition is sprayed onto the strip and the rolls at the entry side of each mill stand.

In Tripathi, U.S. Patent 3,783,664, issued January 8, 1974, it is disclosed that the change in behaviour of a lubricant during its service life is due to changes in the average particle size. Thus, it was recognized that the optimum particle size of the dispersed oil phase is not the same for all oil-in-water lubricant emulsions and that for a particular lubricant there is an optimum range of particle size which can be determined by experiment. Tripathi found that emulsion droplet size in rolling lubricants could be adjusted by chemical means, e.g. by adding a salt to increase the droplet size and adding a soap to decrease the droplet size. However, disadvantages

were found in this chemical means for adjusting the droplet size. Firstly, a significant lag time is required from the time of addition of the chemical until the droplet size changes. Secondly, the addition of chemicals to the emulsion over time begin to change the characteristics of the lubricant.

Currently, oil-in-water emulsions are used to hot roll aluminum ingot and slab to produce reroll. Hot mills often produce a wide range of alloys. Soft and hard alloys require different lubrication conditions in the mill. Conventional hot mills have single coolant/emulsion systems which provide emulsion with one and the same anti-friction and anti-wear characteristics irrespective of alloys or passes rolled. This creates a situation in which the mill produces reroll with good and poor surface quality depending on the alloy or reduces productivity by prohibiting certain passes either due to excessive or insufficient friction. Moreover, due to rolling conditions, the chemical nature of lubricants and metal rolled, and mill construction, hot mill emulsions undergo significant aging which changes their performance throughout their life cycle.

There remains a need for a system to allow adjustment of lubricant emulsion droplet size such as to allow optimization of friction in response to current or computer-projected mill requirements. In this way, there could be a reduction in the number of hot mill passes required to achieve a final gauge of slab, an increase in the rolling speed and or the amount of reduction in the

tandem mill, and an improved quality of rolled product could be obtained.

Disclosure of the Invention

The present invention in its broadest aspect relates to a process for rolling aluminum products in which the aluminum is passed between rolls of a rolling mill and rolling bite friction is controlled by applying to the rolls or less often to the aluminum being rolled a lubricant comprising an oil-in-water emulsion having a specific oil droplet size. According to the novel feature of the present invention, the oil droplet size is adjusted by either (a) blending the emulsion components from a multi-tank storage or (b) passing a large droplet size emulsion through an homogenizer or mixer to obtain droplets of a desired size. The droplet size is selected to optimize the roll bite friction requirements of different sheet aluminum products or rolling mills or to compensate for emulsion degradation due to aging.

When an homogenizer is used, it is preferably in the form of an in-line homogenizer in the lubricant feed line just ahead of the roll bite so that an emulsion of ideal droplet size is continuously delivered to this region of the mill stand. The system of this invention is especially valuable when running different alloys through the same hot mill, e.g. automotive alloys of varying hardness. Thus, rather than having to use a different emulsion blend for each alloy, a simple adjustment in droplet size is made to ensure continued optimum rolling performance. For instance, harder alloys such as 5182 require tighter, i.e. smaller droplet size, emulsion than do softer alloys.

The emulsion is preferably formulated such that by the time it returns to a reservoir for pumping again through the circuit, its surface energy level is substantially at the minimum, i.e. the emulsion is at its loosest or largest droplet size. This provides the option of setting the homogenizer instantaneously to a variety of energy levels depending upon requirements, e.g. as the energy level increases, the emulsion becomes progressively tighter (smaller droplet size).

The alternative of controlling the droplet size by blending emulsion components from multi-tank storage is not as instantaneous as the homogenizer system, but it still represents a much improved system over that described in U.S. Patent 3,783,664. Thus it is still able to quickly adjust the droplet size without the addition of any chemicals that would not be beneficial to the characteristics of the oil-in-water emulsion.

In a typical oil-in-water lubricant composition for use in this invention, the oil phase comprises a hydrocarbon oil base, e.g. a mineral oil fraction with viscosities between 1.8 to 600 cSt at 40°C. Into this oil base are dissolved load bearing additives and surfactants (wetting agents and emulsifiers). The load bearing additives may include fatty acids, fatty acid esters of polyhydric or monohydric alcohols and other esters such as phosphates or borates. The surfactants may be either non-ionic or ionic or a combination of thereof. The non-ionic surfactants may include ethoxylated alcohols, esters, and fatty esters, alcohols and alkyl phenols. The non-ionic surfactants may also originate from polyhydric alcohols

which have only some of their hydroxyl group bound by the fatty acid or ethoxylate to form partial esters or ethoxylates, respectively. The ionic surfactants may be produced by reacting fatty acids with suitable bases such as amines or inorganic and organometallic basic compounds containing metals. The amine-type soap is usually a soap formed from an ethanolamine, which is reacted with some of the fatty acid. It is also usual to incorporate other substances, such as triaryl or trialkyl phosphates (e.g. tricresyl or trioctyl phosphate), as extreme pressure and anti-wear additive, and antioxidants (such as hindered phenols and amines.

In a continuous rolling operation, the average droplet or particle size of the oil phase is either periodically or continuously checked. The oil droplet size distribution is then restored to a value within the range of optimum. This is achieved by either varying the degree of homogenizing or varying the blending ratios of emulsion components.

It is also possible to develop calibration tables whereby droplets of predetermined sizes may be obtained based on the proportions of emulsion components combined to form the emulsion or the mixing or homogenizing conditions used. In this manner, when a different alloy is passed through a rolling mill, the droplet size can immediately be adjusted to the optimum range for that particular alloy.

The emulsion oil droplet size distribution can be monitored either on-line or off-line using either optical or conductivity-based measurement techniques. A method for assessing the average particle or droplet size of an emulsion oil is described in U.S. Patent No. 3,783,664.

The process of this invention can be used not only in hot rolling mills, but also in cold rolling, rolling of thin strip and for processing of other metals by rolling.

Best Modes for Carrying Out the Invention

Example 1

Tests were conducted on a laboratory hot rolling mill for rolling aluminum. The aluminum stock that was used was AA1100.

Emulsions were prepared of large droplet size (loose emulsions) and small droplet size (tight emulsion). The loose emulsion had a medium droplet size of 5.5 microns and the tight emulsion had a median droplet size of 1.9 microns.

The loose "HFR-2" emulsion was prepared comprising a 5% dilution in deionized water of the following composition (w/w %):

40% Quakerol® 740E (neopentyl glycol dioleate ester)

1.5% Igepal® CO-430 (nonionic alkylphenol ethoxylate surfactant - low HLB*)

1.5% Igepal CO-630 (nonionic alkylphenol ethoxylate surfactant - higher HLB*)

1.5% Irganox® L135 (3,5-di-*tert*-butyl-4-hydroxyhydrocinnamic acid, C7-9 branched alkyl esters)

55.5% of mixture of 40% (w/w) Sunpar® 2280 and 60% (w/w) Sunpar LW150 (both are petroleum hydrocarbon oils)

*HLB stands for "Hydrophile-Lipophile Balance"

A tight emulsion was prepared in the same manner as above except that each emulisifier, e.g. Igepal CO, was

present at a level of 3%, thus reducing the hydrocarbon oil mix to 52.5% of the total.

The mill was operated at three different rolling speeds (20, 60 and 100 RPM), two slab entry temperatures (300 and 500°C) and two reductions (20 and 50%). The emulsion were applied to the aluminum alloy before the rolls and the "forward slip" results obtained are shown in Table 1 below:

TABLE 1

Speed [RPM]	Forward Slip [%]			
	high reduction [50%]		low reduction [20%]	
	Tight Emulsion	Loose Emulsion	Tight Emulsion	Loose Emulsion
20	2.0	1.0	4.0	4.0
60	1.5	0	1.5	3.0
100	-3.0	-7.0	0.0	3.0

Forward slip occurs during rolling, and reflects the speed difference between the roll and sheet. It is a significant process phenomenon because it arises as an effect of friction. High forward slip usually indicates high friction while low forward slip indicates low friction. Thus, "positive forward slip" means that the strip speed is faster than the roll speed i.e. caused by the metal exiting the roll bite at a faster rate than it enters due to the reduction in thickness occurring during rolling; "negative forward slip" means that the strip speed is slower than the roll speed i.e. caused by skidding between the rolls and strip. The results indicate that, at a 300°C slab entry temperature, there is a relationship between friction and emulsion oil droplet size. During

rolling at 50% reduction, forward slip was significantly lower with the loose than with the tight emulsions. On the other hand, at 20% reduction the trend was opposite.

The function of a rolling emulsion is to lower the forward slip to an acceptable level. While this is partially alloy dependant, it is often around 5% positive slip. Control of forward slip by mechanically adjusting oil droplet size distribution according to the invention provides significant practical benefits, because excessively high forward slip can lead to surface quality defects on the slab, while negative forward slip can prevent rolling and introduce other types of surface defects due to skidding the rolls on the strip. Thus, the invention can be used to adjust the forward slip ultimately to the optimum level for each alloy being rolled.

Claims:

1. In a process for rolling aluminum products in which the aluminum is passed between rolls of a rolling mill and roll bite friction is controlled by applying to the aluminum being rolled a lubricant comprising an oil-in-water emulsion having a specific oil droplet size,

the improvement which comprises adjusting the oil droplet size of the emulsion to optimize the roll bite friction requirements of different sheet aluminum product or rolling mills or to compensate for emulsion degradation due to aging, the droplet size being adjusted by either (a) blending emulsion components from multi-tank storage or (b) passing a large droplet size emulsion through a homogenizer or mixer to obtain droplets of a desired size.

2. A process according to claim 1 wherein the blending of emulsion components or homogenizing to form the desired droplet size is carried out immediately before a roll bite.

3. A process according to claim 2 wherein the homogenizing is carried out in an in-line homogenizer.

4. A process according to claim 2 wherein the rolling operation is carried out in a hot rolling mill.

5. A process according to claim 2 wherein the rolling operation is carried out in a cold rolling mill.

INTERNATIONAL SEARCH REPORT

International Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B21B45/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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ABSTRACT:

A process is described for rolling aluminum products in which the aluminum is passed between rolls of a rolling mill and rolling bite friction is controlled by applying to the rolls or less often to the aluminum being rolled a lubricant comprising an oil-in-water emulsion having a specific oil droplet size. According to the novel feature, the oil droplet size is adjusted by either (a) blending the emulsion components from a multi-tank

storage or (b) passing a large droplet size emulsion through an homogenizer or mixer to obtain droplets of a desired size. The droplet size is selected to optimize the roll bite friction requirements of different sheet aluminum products or rolling mills or to compensate for emulsion degradation due to ageing.